

EPRI Perspective

Fuel Cells in Evolving Energy Markets

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Perspectives on 1996 Technology Progress

During the past year, fuel cell technology for stationary power applications continued to advance in both commercial applications; first of a kind field demonstrations; and laboratory scale breakthroughs. PAFC systems are carving out a real niche as premium power and grid independent power systems for commercial sector markets. Field units continue to illustrate fuel cell systems can have superior reliability and availability characteristics. While costs are still about a factor of two higher than what more main-stream markets will bear - PAFC applications & adoption process clearly point the way in demonstrating how fuel cells will play out in the evolving energy services markets.

Multi-million dollar carbonate fuel cell field tests were completed the past year. A 2 MW system developed by ERC successfully operated for 4090 hours sending power to the Santa Clara electric grid. A 250 kW pilot system supplied by M-C Power also completed demonstration tests with over 1500 MWhs supplied to the Miramar Naval Air Station. Both these demonstrations are enormous steps forward in developing an understanding of how carbonate systems need to be designed and how carbonate stacks need to be configured both electrically and process wise. While these demonstrations provided valuable information for the developers, they fell short, however, in providing the necessary “technology comfort” for many of EPRI’s electric and gas utility clients. More specifically, the demonstrations did not confirm if large carbonate stacks can be effectively cycled and provide load following. They also did not answer important buyer questions on durability; performance, life and information regarding costs and impacts of long term operation on maintenance and operations. As both carbonate fuel cell demonstrations fell short of their intended operating test plans, concerns need to be raised regarding the robustness of the technology that was put in the field; the relative timing of these field tests; the need for continued RD&D “in-house”; and eventual commercialization plans. As will be discussed later, fuel cell technology is trying to be introduced into an rapidly changing electric power industry, where it will be very difficult for utilities to be the early adopters and initial buyers of potentially high risk technology. New and creative commercialization approaches will be needed.

Solid oxide fuel cell systems are advancing both in size and in integrated systems coupled with small gas turbines. Westinghouse has fabricated and is testing a 100 kW system; ZTEK has fabricated and is testing a 25 kW planar system. Both are planning to enter the market with ultra high (60%) SOFC-gas turbine systems. Innovations in the laboratory have yielded breakthrough power densities. EPRI sponsored work at the University of Utah developed a planar solid oxide fuel cell with a power density 5-6 times higher than the current state of the art.

Historically, PEM fuel cells did not fit into any EPRI advanced power generation systems. However, both the industry and the technology has changed and we believe there are several strategic fits for PEM fuel cells. Polymer electrolyte membrane fuel cells continue to make technological advances in both increased power density; weight reduction; and cost reduction. As such, we are starting to look very closely at PEM systems for stationary power markets and applications. Their operating and power characteristics may make PEM systems potentially very attractive in new energy services. The past year has also shown that fuel processing systems, once a critical enabling technology for PEMFCs, are also advancing. Examples of this are the work at ADL and Northwest Power. Advances in PEM technology are also leading us to re-examine the role of PEM electrolyzers and regenerative PEM systems in energy market applications. If critical technical issues can be resolved this may open up complete new markets for PEM fuel cells in stationary power and transportation markets.

Role for Fuel Cells in Evolving Electric Utility Industry

Electric industry restructuring is radically evolving to a new paradigm where customers will be able to purchase electricity as a commodity. New energy service providers will emerge to “package” and offer a wide variety of energy service products to customers. Customers will have a landmark opportunity to choose their own energy providers. These structural changes, deregulation and the resulting competitive environment will significantly impact commercialization strategies and markets for fuel cell technology.

While electric and gas utilities have historically pioneered the introduction of new technology, the associated risks of using “emerging technologies” were moderated by monopoly status and allowance for rate-based costs to be passed on to customers. New regulatory changes favor enhanced competition, lowest-cost providers, and differentiated services that deliver value to customers beyond traditional kilowatts. Therefore, utilities will not be able to provide the “market pull” support in the way previously envisioned for commercialization of fuel cells. Competing technologies continue to place pressure on the performance and cost requirements for fuel cell products. Compact aeroderivative turbines and proven heavy-frame (industrial) gas turbines are commercially available in 1 to 100 MW sizes and can be deployed on a one-year schedule; several micro-turbine generator systems are also entering the market for on-site distributed power generation applications. Their initial low cost (\$ < 500/kW) and attractive operating characteristics are receiving the attention of many of our utility clients.

We do not believe fuel cells will be competitive with bulk power generation resources for quite some time, if ever. That is, it will be very difficult for fuel cell systems to compete in a deregulated bulk power commodity market. Fuel cells will most likely find applications in a variety of distributed generation/energy services applications.

The most likely adopters of fuel cells will be non-regulated Energy Service Companies (ESCOs) offering packaged bulk power and valued added services to customers. ESCOs will favor fuel cell products in the 10 kW to 5,000 kW sizes. GENCOs and Mini-Gencos may adopt larger fuel cell products (e.g. 1 to 20 MW SOFC-CT and MCFC systems) if they can compete with bulk power or offer other quantifiable values to end use customers. Fuel cell produced

power will be used to augment bulk power most-likely through a premium service or cogeneration driven customer need. Near term applications could be in industrial and commercial cogeneration sites where electric and gas rates are high; in certain commercial sectors where high reliability and premium service will be valued high enough to off-set the higher cost of fuel cell power. Early adopter markets are most likely to be in the commercial sector which could include hotels; data processing centers; grocery stores; health care and educational facilities. Eventual mass markets could be served by either PEM or SOFC systems designed for loads around 2 to 10 kW. However, significant technical and cost reduction challenges exist for fuel cells in this market.

The electric utility industry is entering into a competitive era in which the business environment requires investments in new technology to provide an immediate as well as long term return. Electric utilities seek to deploy new technologies that respond to customer needs and enhance their ability to compete on a domestic and global basis. Several of our member utility clients have recently made significant investments in fuel cell technology ventures.

Reinventing EPRI's Fuel Cell & Distributed Generation Program

Industry restructuring, the convergence of electric, gas and telecommunications are requiring EPRI to re-invent the collaborative R&D business model upon which the Institute was founded 25 years ago. During the past three years we have unbundled our R&D portfolio which now enables utilities to choose among 100 research targets and to customize their participation in EPRI R&D. We have also recently established two taxable subsidiaries epriCSG and epriGEN to enhance the competitive value of R&D investments by our members and to provide increased flexibility with respect to intellectual property protection, publication and access of information.

The new corporate vision for 1998 is to "Provide science and technology based solutions of indispensable value to our global energy customers". We are in the process of changing our organization from a structure designed to serve an integrated utility to one that will provide solutions to numerous individual participants in the electric and energy enterprise including: power marketers; generating companies; transmission and distribution companies; system operators; gas and oil companies; energy service and retail service companies; and telecommunications companies.

Fuel Cell R&D at EPRI has undergone dramatic changes in program emphasis and direction. All future long term fuel cell R&D and basic science & technology will continue to be funded by our strategic R&D program. While the development and commercialization of new fuel cell products for retail and small distributed power markets will be very much market driven and conducted in our new epriGEN taxable subsidiary target. Our fuel cell program has changed the past few years from a "technology push" R&D strategy to more of a market and "customer driven" R&D focused program.

Our program areas for 1998 include:

- Evaluate ONSI 200 kW PAFC systems in distributed generation applications

- Facilitate the commercialization and early introduction of MCFC systems
- Provide intelligence and assessments on vendor fuel cell programs
- Sponsor development of SOFC based systems for serving retail markets
- Participate in development, evaluation, and demonstration of SOFC-CT systems
- Evaluate & develop PEM based fuel cell systems for retail markets
- Catalyze the formation of initiatives, joint ventures involving fuel cell technology

Our primary goals are to provide intelligence and fuel cell technology solutions to our clients to help them grow new and profitable business strategies based on advanced distributed resource technologies. By participating in bench scale testing, evaluation, development and demonstration we will provide validated data to support member interests in fuel cell technology investments. EPRI is in a unique position to assist both energy companies and fuel cell developers in defining/developing marketable products and in implementing their commercialization business plans within the evolving restructured electric power industry.